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A PROJECT BOOK

Making working Models

PROJECT BOOK
196

TOYS AND MODELS

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PROJECT BOOK 196

By R. H. Warring

Illustrated by Roy Palmer

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PART ONE

The simplest way to drive your models

Models that work are always much more interesting than those you can only look at. To work, a model has to have some sort of *power* to drive it. Until about 20 years or so ago, there were only three types of motors suitable for powering models:

1 clockwork motors.
2 rubber motors.
3 steam engines.

Today there are many more. Small electric motors driven by batteries and costing only a few shillings to buy; the glow motor and the Diesel engine which have become the main type of power units for model aircraft; even rocket engines.

The clockwork motor is hardly used at all these days for models. It does not have much power for its size, does not run for very long, and costs more to make than a simple electric motor. Even for toys it has been replaced by the 'push-and-go' type motor which uses a heavy flywheel to provide power. The *push* starts the flywheel spinning—the faster you can get it spinning the better—and the energy stored in the flywheel makes the toy *go* when you place it back on the ground.

PROJECT

'Push and go'

You can use the 'push-and-go' mechanism taken from an old toy to propel simple model cars you have made yourself. Cut a new base from plywood. Fit this with the drive unit and wheels, and the front wheels from the toy. Carve a body shape from balsa and hollow it out to fit over the top. This can then be cemented in place to the ply base.

The steam engine, too, is little used for working models today. Even a simple steam engine is quite difficult to make, or expensive to buy, and it develops very little power. Many small steam engines, in fact, only develop enough power to make themselves run. They have no power to spare to drive anything else. But, of course, a steam engine by itself *is* a working model.

Rubber powered models

A rubber motor is quite different. It is something for *powering* a model, and it cannot work on its own. It has to be part of the model, and the model has to be made to take a rubber motor in the form of a rubber band, or a loop of rubber, which can be wound up. When released the wound up band then unwinds to provide power for driving something.

PROJECTS

A helicopter

Rubber motors were used for powering simple model aeroplanes as long ago as 1870. *Fig. 1* shows how to make a model of a type which was very popular at the time. It is a simple *helicopter*, which can be made to fly quite well indoors.

Cut an 8 in. length of $\frac{3}{16}$ in. square balsa for the stick. Bend

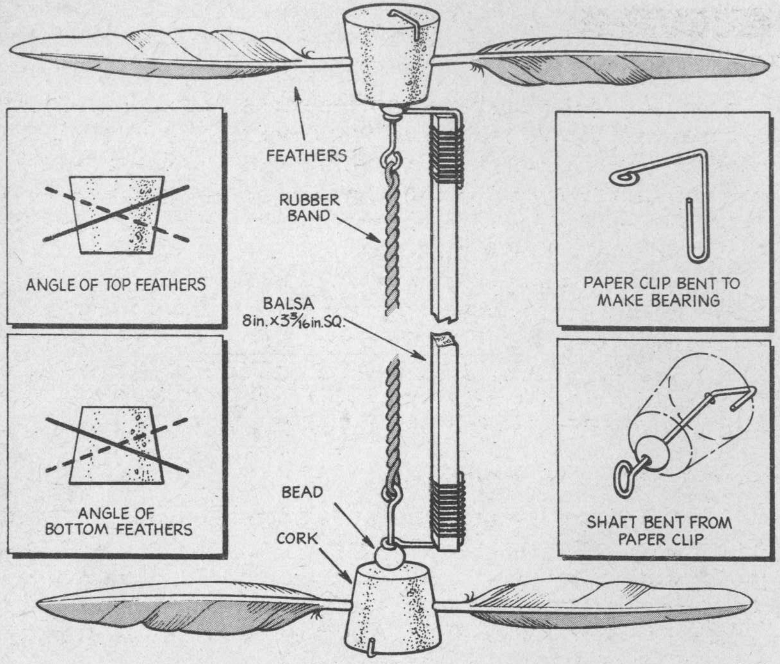


Fig 1

two simple bearings to the shape shown from paper clips and bind one to each end of the stick with cotton. Straighten out two more paper clips and bend to the shaft shape shown. Each shaft is pushed through the bearing, a small bead added and then a small cork. Finally turn the end of the wire over with pliers and push back into the cork.

Collect four bird wing feathers about 5 in. long, all as near the same size as possible. Make holes in each side of the corks and push the feathers into the corks. Set them so that each feather in the same cork has an opposite 'twist' like a propeller. The twist on the bottom 'propeller' must also be the other way round to the twist on the top one.

Loop a thin rubber band between the two shafts, hold one 'propeller' and wind up the rubber motor by turning the other propeller. Wind on about twenty or thirty turns and then let the model go and see it fly. If it flies downwards, you have wound up the rubber band the wrong way.

By adjusting the 'twist' of the feathers, and winding on more turns on the rubber band, you should be able to get quite good flights with this model.

You will get better flights if you make two new propellers with balsa sheet blades slotted into a balsa hub, as shown in *fig. 2.* Cut the slots carefully with a small saw and cement the ends of the blades in position.

Making a rubber-powered 'tank'

Another very simple rubber-powered model is shown in *fig. 3.* For this you need: a cotton reel; a short rubber band; a toothpick (or a piece of thin wood about 4 in. long); a slice about $\frac{1}{4}$ in. thick cut off the end of a candle; a matchstick and a pin (bent to a U-shape as shown).

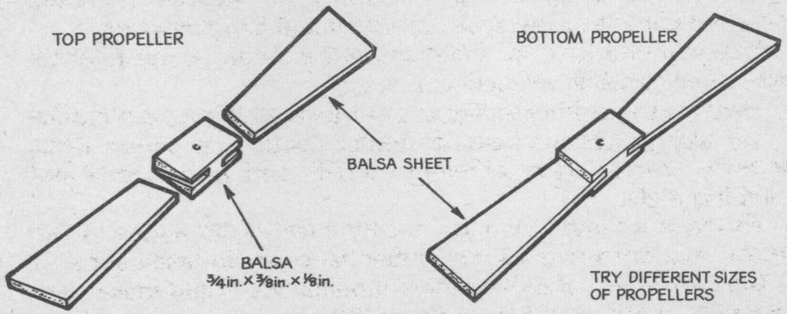


Fig 2

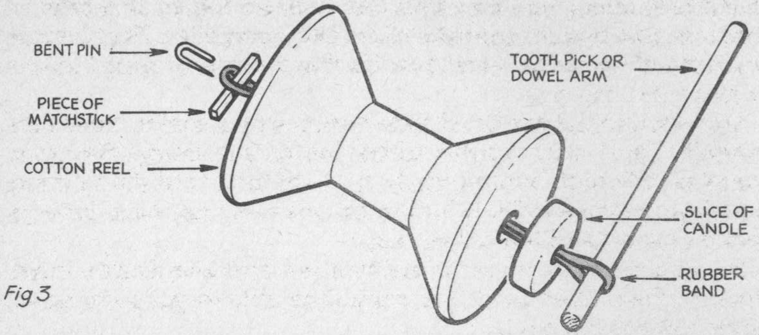


Fig 3

Make a hole through the centre of the slice of candle and assemble the model as shown. The matchstick is passed through the other end of the rubber band and held to the side of the cotton reel with the bent pin.

Wind up the model by turning the arm round and round about twenty times, then place it on a flat surface. It should crawl forward at a slow speed as the rubber band unwinds.

You will find that this little tank has enough power to climb over small obstacles placed in its way.

Here are some other things you can try with this type of model.

Try using different sizes of rubber bands and cotton reels, or build two or three different models and have speed and climbing trials.

To make a better 'climber' cut notches in the edges of the cotton reel; or stretch a short rubber band around each edge.

Can you think of other simple models you could make with this as a 'power unit'? How about fitting a proper tank-shaped body around it, made from sheet balsa?

PART TWO

Rubber-powered boats

PROJECT

Draw a hull shape on a 9 in. length of 3 in. × $\frac{1}{2}$ in. balsa sheet and cut out. Cut off the two terminal strips on a $4\frac{1}{2}$ volt flat battery, using scissors, to make the two metal shapes shown in *fig. 4*. If you cannot find an old battery, cut these shapes from an empty tin.

Pierce a large hole in one end of the bearing strip, and a smaller hole in the other end. Fix the bearing strip to the back of the balsa hull with a woodscrew, as shown.

Straighten out a paper clip and bend one end into a loop. Pass the other end through the hole in the bearing strip, slip on a small bead, and then bend the rest of the wire back on itself. Slip the propeller in place, as shown, and cut off surplus paper clip wire.

If you can use a soldering iron properly, solder the propeller to the wire. If not, glue the propeller to the wire with Araldite.

To complete the model, bend a front hook from another paper clip and push this into the bottom of the hull near the bow. Add a rubber band between the two hooks. Finally twist the two propeller blades in opposite directions and your rubber powered boat is ready for its trials.

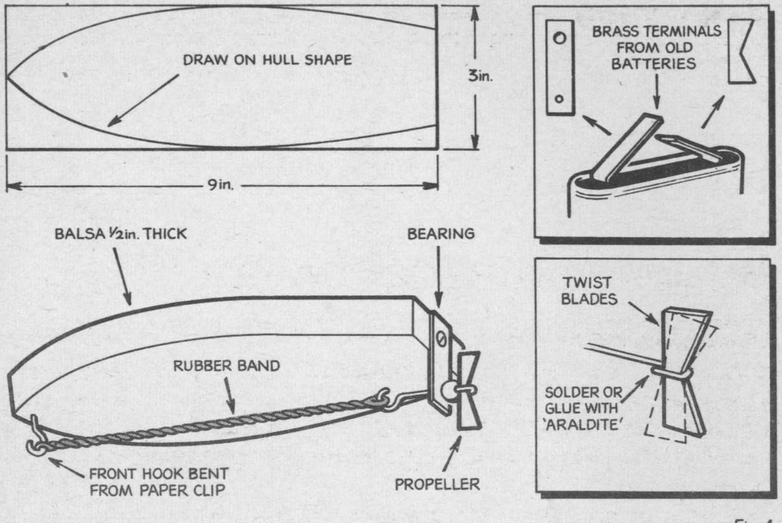

DRAW ON HULL SHAPE
3in.
9in.
BRASS TERMINALS FROM OLD BATTERIES
BALSA ½in. THICK
BEARING
RUBBER BAND
FRONT HOOK BENT FROM PAPER CLIP
PROPELLER
TWIST BLADES
SOLDER OR GLUE WITH 'ARALDITE'

Fig 4

These you can carry out in the bath. Wind on the propeller several turns with a finger. Place the model in the water and let the propeller go. It should travel forwards steadily as the rubber band unwinds.

Further ways to experiment

The model will probably not run straight, so add a rudder, and once again try lifting out your model with a superstructure cut from balsa sheet to make it look more realistic.

There are plenty of other models of this type you can make which can have a power run long enough to travel right across a small pond. You can also make rubber-powered submarines—see Project Book No. 194 **Making Model Ships.**

PART THREE

Airscrew-driven models

The best way of using rubber motors is to make them drive an airscrew—just as they do in the case of rubber powered model aeroplanes. An *airscrew* drive can also be used to propel model cars and boats at quite high speeds.

PROJECT

Making a dragster

How to make an airscrew driven dragster is shown in *fig. 5.* The chassis of the car is quite easy to make. Cut the main beam to a $6\frac{1}{2}$ in. length from a piece of hard $\frac{3}{8}$ in. × $\frac{1}{4}$ in. balsa strip. Cut two axle beams from $\frac{1}{4}$ in. × $\frac{1}{8}$ in. balsa strip, then also cut two wire axles to match and bind to these beams with cotton, followed by a coat of cement to hold the binding in place. Cut notches in the main beam to take the two axle beams and cement them in place, as shown.

To complete the chassis unit, cut the pylon piece from $\frac{1}{4}$ in. sheet balsa and the two bracing pieces from $\frac{1}{8}$ in. sheet balsa, and cement in place. The airscrew is a 5 in. diameter plastic model aeroplane propeller. Mount on a brass bearing bracket secured to the top of the pylon, as shown. Use 20 or 18 gauge

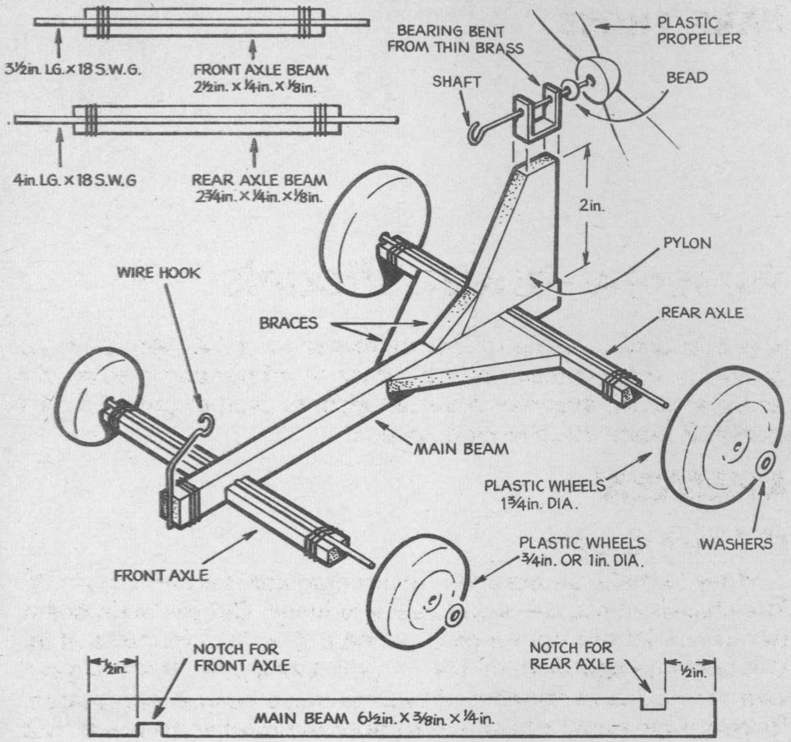


Fig 5

wire for the airscrew shaft. The front hook is bound from the same size of wire and bound to the front of the main beam.

The rear wheels are 2 in. diameter balsa balloon wheels sanded down to a flat shape to look like real dragster tyres, or

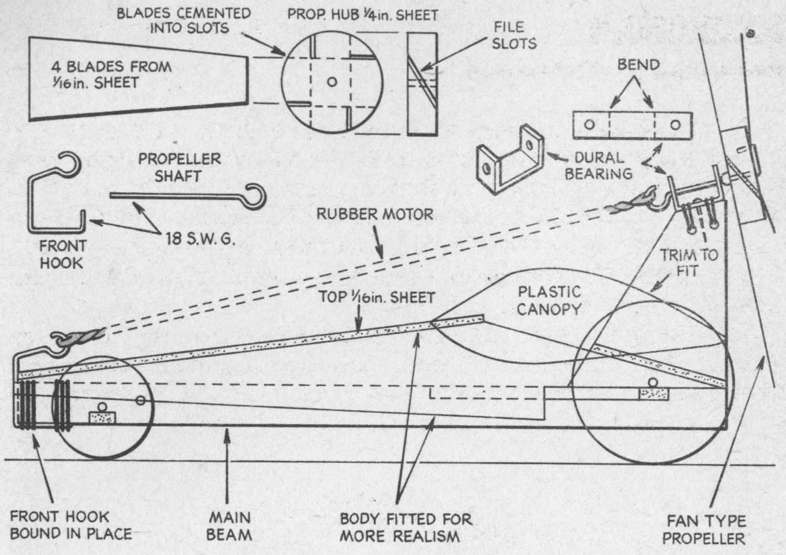


Fig 6

you can just use $1\frac{1}{2}$ in. diameter balsa or plastic wheels, if you like. Hold on to the axle with a washer at each end soldered in place, or glued. The front wheels are $\frac{3}{4}$ in. or 1 in. diameter plastic wheels, secured on the front axle in a similar way with washers.

The model is then ready to go as soon as you have added a rubber band motor and wound it up. Try it out over a nice smooth surface. Add another band, or even two, if you want more speed. If you want a longer distance run, increase the length of the rubber motor by using two bands tied together to double their length.

Improved performance

1 You should be able to improve the performance of the model just described by using a fan-type airscrew, in place of a bought plastic propeller, as shown in *fig. 6*. The hub is a 1 in. diameter circle cut from $\frac{1}{4}$ in. sheet balsa. Cut slots as shown very carefully with a flat file. Cut four blades from $\frac{1}{16}$ in. sheet balsa and cement into these slots. Mount the airscrew on a shaft just as you did with the plastic propeller.

2 Experiment with different size motors to get the best results. The motor can be longer than the distance between the front and rear hooks. Use a winder to wind up the motor which you can see in a later diagram (*fig. 10*).

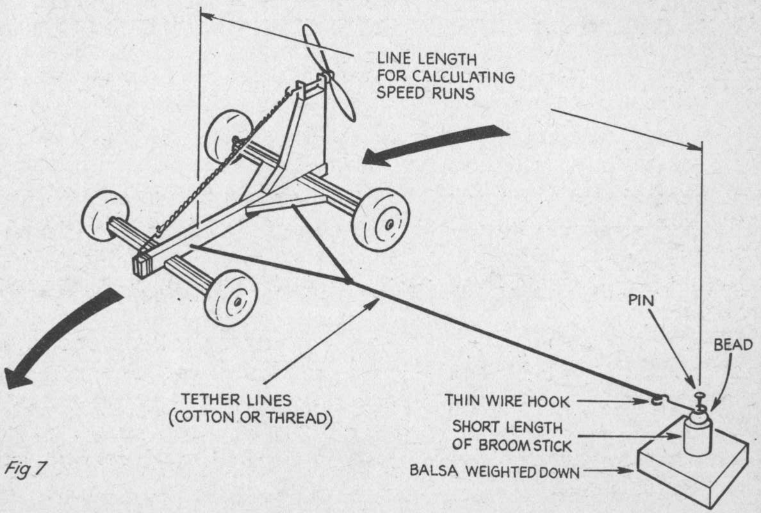

LINE LENGTH FOR CALCULATING SPEED RUNS
PIN
BEAD
TETHER LINES (COTTON OR THREAD)
THIN WIRE HOOK
SHORT LENGTH OF BROOM STICK
BALSA WEIGHTED DOWN

Fig 7

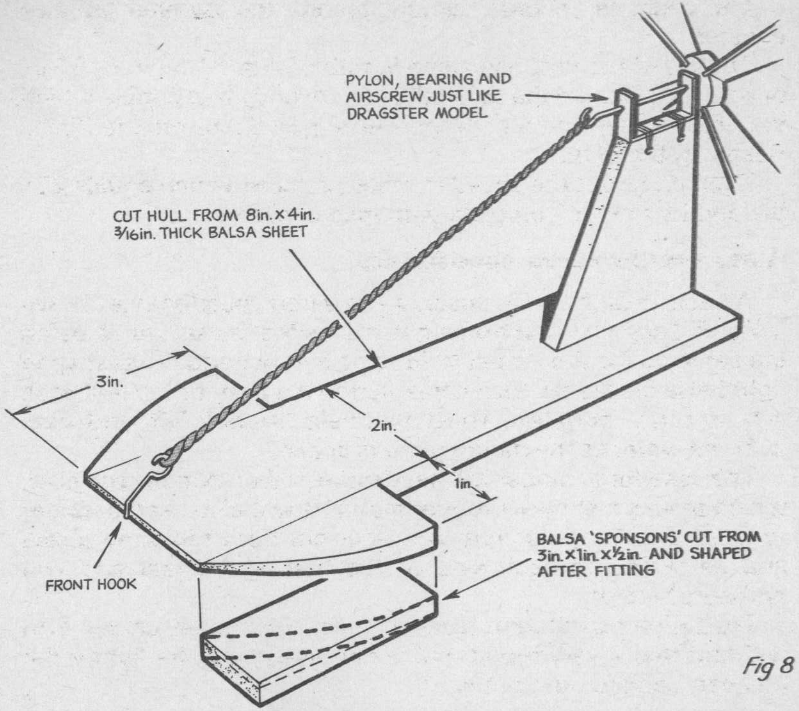


Fig 8

3 You can add various body shapes to the chassis, cutting these from thin sheet balsa and building up in the form of a box. Or you could carve a body shape to fit from solid balsa. If you do, hollow it out to reduce weight.

4 For running indoors, you can tether the model to run in a cricle, as shown in *fig*. 7 on the previous page. Then you can make 'speed' and 'distance' runs, set records, and have contests with friends who have also built rubber-powered dragsters.

For distance records, simply record the number of laps covered.

For speed records, use a line length of 4 ft. 4½ in., 6 ft. 3¾ in. or 8 ft. 9 in. Record the time taken to cover $\frac{1}{16}$th of a mile, which would be 12 laps on 4 ft. 4½ in. line length, 8 laps on 6 ft. 3¾ in., 6 laps on 8 ft. 9 in.

Then work out the speed in miles per hour which equals 225 divided by time to complete $\frac{1}{16}$th mile in seconds.

Airscrew-powered speedboats

A basic design for an airscrew-powered speedboat is shown in *fig*. *8*. The hull is cut from light $\frac{3}{16}$ in. sheet balsa, with a pylon the same as for the dragster fitted at the rear end. Two shaped light balsa blocks are then cemented to the front of the hull each side to form sponsons. These will help the hull 'lift' and skim over the water as the model gathers speed.

The speedboat model will need more power than the dragster, which means a stronger rubber motor. It will also need a rudder to keep it running straight. A rudder cut from this sheet balsa and cemented to each side of the hull at the rear end will probably be best.

Try designing different types of hulls for airscrew-power. You will find that a very broad hull is necessary, but the lighter the hull can be made the better.

PART FOUR

More about rubber motors

Rubber bands are usually of square section about $\frac{1}{16}$ in. square, or flat, either $\frac{3}{16}$ in. or $\frac{1}{4}$ in. wide. They are available in lengths up to about 12 in. although you may have trouble trying to find any more than about 6 in. long in local shops. For any rubber motor longer than about 6 in. therefore, the best thing to use is *aero strip*. The most common size for this is $\frac{1}{4}$ in. wide, and you can buy it in any length you want from a model shop.

PROJECT

Making up a rubber motor from aero strip

Rubber motors are usually made up of an even number of strands. A single loop would be two strands; two loops, four strands, and so on. The length of the motor, and the number of strands, decide the total length of rubber strip you require.

For a two-strand motor you need a length of rubber strip about 3 in. longer than the motor length required. This is to allow for tying the ends together in a knot. Always use the type of knot shown in *fig. 9*. For a four-strand motor you need four times the motor length, plus 3 in. for knotting. Tie into a single loop, and then double the motor back on itself to make a four-strand motor.

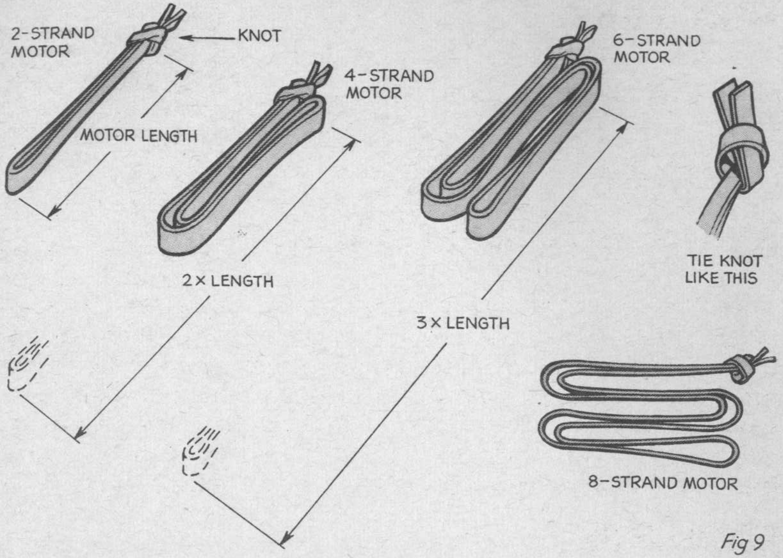


Fig 9

Six-strand and eight-strand motors are made up in a similar way—which you can also see in *fig. 9*.

Increasing the number of strands increases the power the motor will give.

Increasing the length of a motor increases the number of turns you can put on it without the rubber breaking, and so increases the length of power run when the motor is unwinding. This time the increase is directly proportional to the length. Doubling the length will double the number of turns the motor will take, and double the unwinding time.

To increase both the power and the length of motor run, therefore, the motor would have to have more strands, and be made longer as well.

Check these three facts by experimenting with your airscrew-powered models.

A rubber motor will last longer, and it will also take more turns without breaking, if it is lubricated. There are only two suitable lubricants—castor oil, and rubber lubricant which can be bought at model shops.

In an emergency, you could use father's shaving cream as a lubricant!

The following table gives the maximum 'safe' turns for lubricated rubber in two different sizes for various numbers of strands. The figures are for turns per inch of motor length. To find the maximum turns for any motor length, multiply by the motor length in inches.

For example, suppose you were using a four-strand motor made up from a ¼ in. strip and the motor length as 12 in. From the table below, a four strand ¼ in. strip motor will take 46 turns per inch. So a 12 in. long motor will take 12 × 46 which equals a maximum of 552 turns.

TABLE

No. of strands	2	4	6	8	10	12	16
¼ in. strip	60	46	36	30	26	24	20
3/16 in. strip	66	50	40	35	30	28	26

Stretch-winding helps

To get maximum turns on a rubber motor safely, stretch-winding should be used, together with a hand drill as a winder. Hook the drill onto one end of the rubber, start winding and move out until the motor has been stretched to three times its original length. (*See fig. 10.*) Stay in this position until you have wound on about two-thirds maximum turns, then come in as you wind on the remaining turns.

You will need someone to hold the model when you 'stretch-wind' a rubber motor.

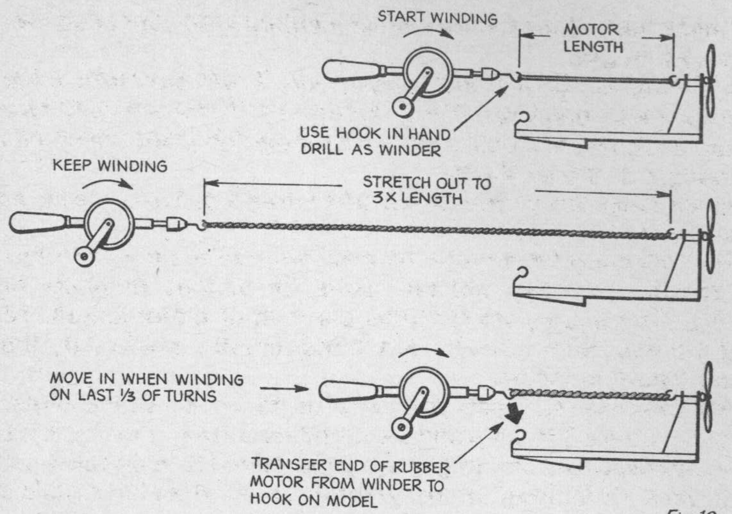

START WINDING
MOTOR LENGTH
USE HOOK IN HAND DRILL AS WINDER
KEEP WINDING
STRETCH OUT TO 3× LENGTH
MOVE IN WHEN WINDING ON LAST ⅓ OF TURNS
TRANSFER END OF RUBBER MOTOR FROM WINDER TO HOOK ON MODEL

Fig 10

If you want your motor to last longer do not wind it to its maximum unless you are trying to set a record, or win a competition, with a rubber-powered model. This will reduce its useful life. For normal use, do not wind a rubber motor beyond three-quarters of its maximum turns. It should then remain in good condition for a long time.

PROJECT

More fun from models

To obtain more fun from your models check the maximum turns figures given by the table, for yourself. You can probably get better figures if the aero strip you have bought is top quality. Also check maximum turns for aero strip (a two strand motor) against the figure you can get from a rubber band of the same width. Then try different sizes and samples of rubber strip for maximum turns.

These tests will show you which is the 'best buy'.

Make up your own rubber lubricant by gently simmering two parts green soft soap (unscented) and one part glycerine in an old saucepan. Stir regularly until well mixed, then allow to cool. Pour into a bottle and label 'Rubber Lubricant'.

PART FIVE

Electric motor drives

The cheapest electric motors you can buy, with enough power for driving small models, are about 15p Prices then go up with increasing size and power, but there are at least a dozen or more still costing under 50p No wonder electric motors are the most popular choice for powering model boats and cars, or driving other types of working models. The only type of model they are not suitable for is a model aeroplane. By the time you have added a battery the weight is too much.

All these small motors are of the low voltage type, running off three volt to six volt batteries. Although these batteries are not very expensive, an electric motor driving a working model takes quite a lot of current from a battery—enough to run a small dry battery down in a matter of minutes sometimes. That means that the running cost of an electric powered model can be quite high.

How to reduce running costs

The best way of reducing running costs is to use a rechargeable battery with an electric motor. Special types of accumulators, known as DEAC's, are quite small in size and provide ample power for electric motors. When they are run

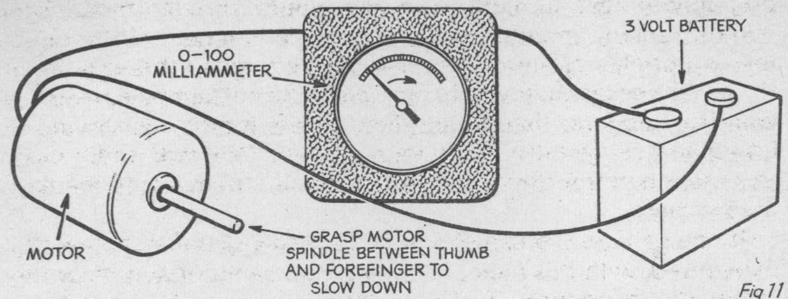


Fig 11

down, they can be recharged and used over and over again. But there are two problems.

The cost of a rechargeable battery is quite high. You would probably use up a dozen or more sets of dry batteries before you had spent the same amount as for a DEAC battery.

You need a special charger for recharging DEAC's. This again costs money—at least 150p probably more.

Most modellers, therefore, still use dry batteries. The way to make them last longest is to make sure that the electric motor runs as fast as possible when driving the model. Then it draws much less current from the battery. This can be shown by a simple experiment.

PROJECT

Electric motor

Connect a 0–100 milliammeter in circuit with a small electric motor and a suitable battery (*fig. 11*). If you do not have a milliammeter, or cannot borrow one, this experiment could be done in the science lab at school.

Since the motor is not driving anything it will run very fast—probably as fast as 5,000 revs per minute, or even more. The current drawn, as indicated by the milliammeter, will be quite low—probably around 20 milliamps. Now grasp the spindle of the motor to slow it down. Immediately the milliammeter reading will rise, showing that adding load to the motor has slowed it down and caused it to draw more current. You will find it easy to slow the motor down enough for a full 100 milliamp reading on the meter.

If you can get the use of a 0–1000 milliamp meter, repeat the experiment with this meter in circuit. You can probably slow the motor down enough to draw 1000 milliamps. No wonder a small dry battery will not last long if the motor is driving at that speed!

Geared-down drives

Suppose you wanted to use a small electric motor to drive a model car, and connected one rear wheel directly to the motor spindle. Even when the car had picked up speed and was running fairly fast, the motor itself would still only be running

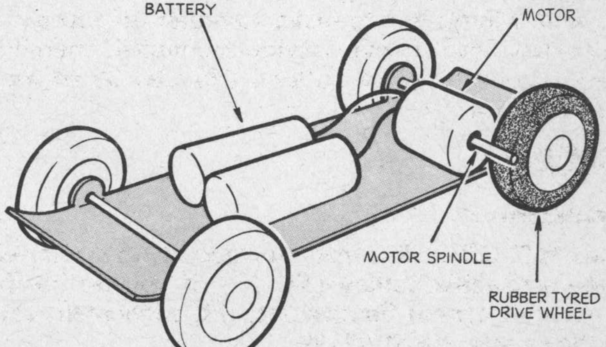


Fig 12

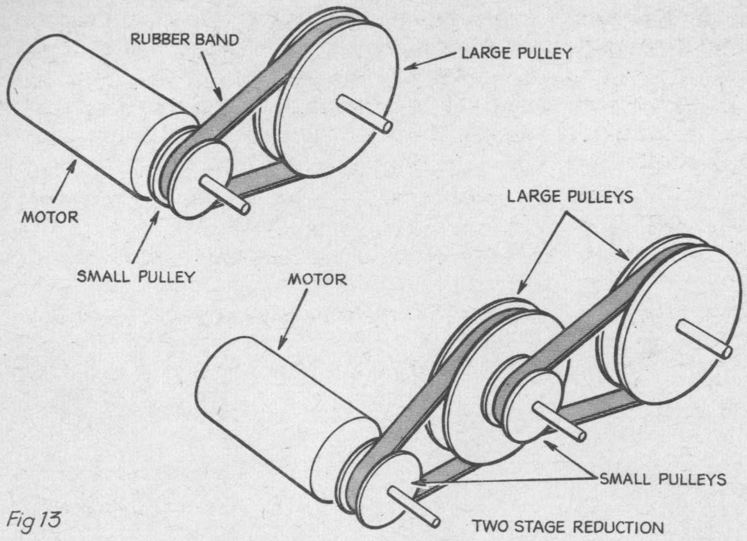


Fig 13

quite slowly, and drawing a very high current.

A much better way is shown in *fig. 12.* The drive wheel on the car is rubber tyred and the spindle of the motor presses against the tyre so that the motor completes perhaps twenty revolutions whilst the drive wheel completes one. The motor can thus run fast and still drive the car with friction connecting the motor spindle and drive wheel.

This is a simple method of powering a small model car without having to use gears to get a speed reduction between the motor and driven part (the drive wheel of the car). You can use it for making free running models out of plastic kit cars; or for making your own slot-race cars. (See also Project Book No. 197 **Making Model Cars.**

To see how you can get speed reduction using pulleys and a belt drive (a rubber band makes an excellent drive belt) study *fig. 13.* You can easily work out the speed reduction. This is given by dividing the diameter of the *drive* pulley by the driven pulley. If the drive pulley is $\frac{1}{4}$ in. diameter and the driven pulley 1 in. diameter, the speed reduction would be one to four.

This is still not a very high reduction, so we can add another stage, if necessary, as shown in the second diagram.

In this case the speed reduction would be 1 to 4 × 4 = 1 to 16.

Here are some standard sizes of plastic pulleys you can buy in model shops.

$\frac{1}{4}$ in., $\frac{5}{16}$ in., $\frac{3}{8}$ in., $\frac{1}{2}$ in., $\frac{3}{4}$ in., $1\frac{1}{4}$ in., $1\frac{1}{2}$ in.

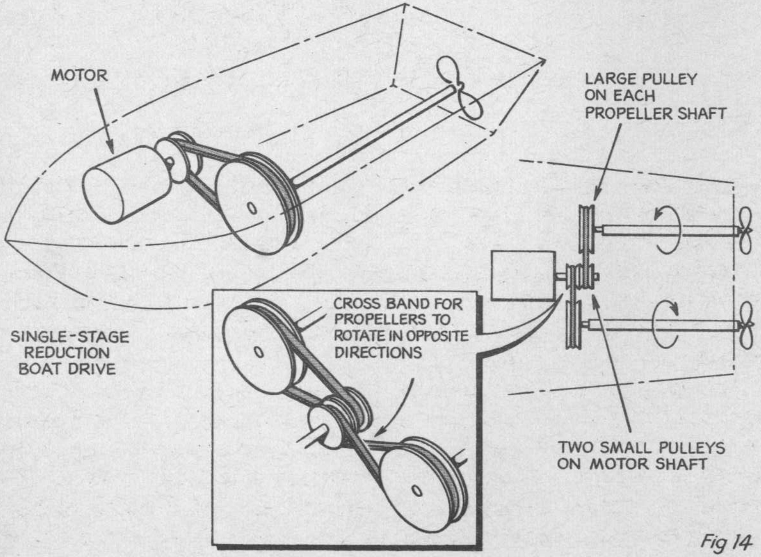


Fig 14

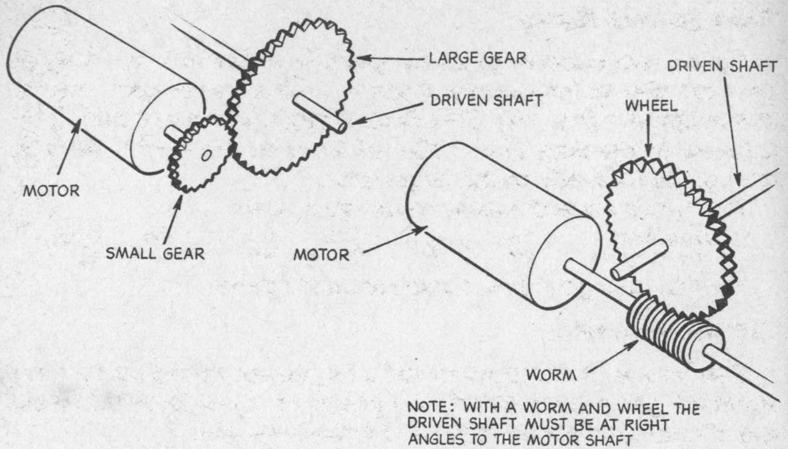

LARGE GEAR
DRIVEN SHAFT
MOTOR
SMALL GEAR
DRIVEN SHAFT
WHEEL
MOTOR
WORM
NOTE: WITH A WORM AND WHEEL THE DRIVEN SHAFT MUST BE AT RIGHT ANGLES TO THE MOTOR SHAFT

Fig 15

You can now try working out what is the maximum speed reduction you could get in a single stage (smallest pulley driving the largest pulley), or what other speed reductions could you get with other combinations of pulley sizes and two-stage reductions?

Speed reduction using pulleys takes up quite a bit of room, so you cannot use them on many types of models. A single stage reduction drive could be used in a model boat, as shown in *fig. 14*. The second diagram shows how a single electric motor can be used to drive twin screws in a model boat, again with speed reduction. Either method is better than the usual way of connecting the electric motor shaft directly to the propeller shaft, if you want to make your batteries last longer.

Other models such as *windmills* can be powered by electric motors and pulley drives.

True geared drives

Speed reduction is given by gears in a similar way. A small gear on the motor spindle meshes with a larger gear on the driven spindle (*fig. 15*). This time, though, the speed reduction is found by dividing the number of teeth on the smaller gear by the number of teeth on the larger gear.

Here are standard plastic model gear sizes:

Diameter	$\frac{3}{8}$ in.	$\frac{9}{16}$ in.	$\frac{13}{16}$ in.	1 in.	$1\frac{1}{4}$ in.	$1\frac{1}{2}$ in.
No. of teeth	10	20	30	40	50	60

You can use gear drives just like pulley drives.

Try for yourself

Can *you* work out how to get a higher speed reduction from standard gears than standard pulleys or what is the greatest speed reduction you can get in a two-stage drive?

Can you spot one important difference between pulley drives and gear drives?

With a pulley drive both the driving and driven shafts rotate in the same direction (unless you 'cross' the rubber band connecting them). With geared drives, the driven shaft always rotates in the opposite direction to the driving shaft.

What other differences are there between the two?

Worm and gear sets

There is one way to get a high reduction with gears. That is to use a special gear called a worm on the motor spindle, driving a large toothed 'wheel', as shown in the second diagram (*fig. 15*). This way you can get a speed reduction of 1 to 30 or 1 to 40 or more quite easily. Unfortunately, though, this form of drive wastes a lot of power through friction, which slows the motor down even more. Pulley drives, or geared drives are usually best for working models driven by electric motors.

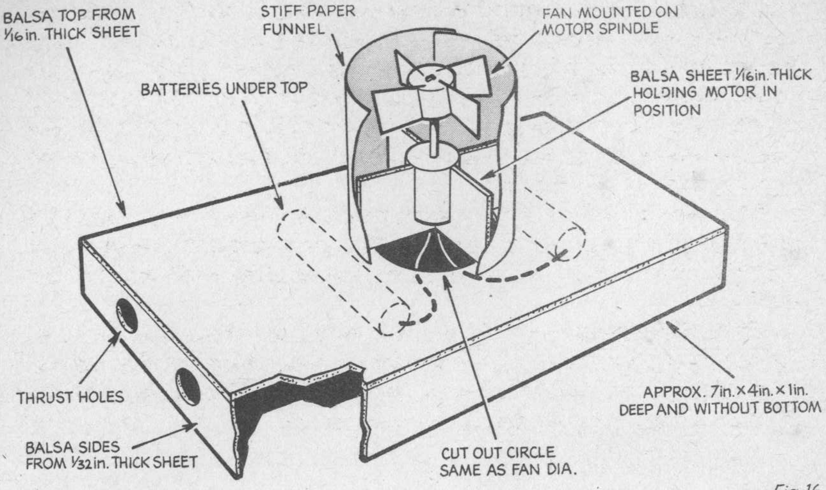

BALSA TOP FROM 1/16 in. THICK SHEET
STIFF PAPER FUNNEL
FAN MOUNTED ON MOTOR SPINDLE
BATTERIES UNDER TOP
BALSA SHEET 1/16 in. THICK HOLDING MOTOR IN POSITION
THRUST HOLES
APPROX. 7in.×4in.×1in. DEEP AND WITHOUT BOTTOM
BALSA SIDES FROM 1/32 in. THICK SHEET
CUT OUT CIRCLE SAME AS FAN DIA.

Fig 16

PROJECT

Making a Hovercraft

A small electric motor can drive a simple fan fitted to its spindle and still run quite fast. The fan will not provide enough thrust to use as an airscrew drive for models like those in Part Three, but it can be enough to power a model Hovercraft—see *fig. 16*.

The body of the Hovercraft is a simple tray shape made from very light $\frac{1}{32}$ in. sheet balsa. The fan can be made in the same way as *fig. 6*, but should be smaller. The diameter should be two-and-a-half to three times the diameter of the motor.

Mount the motor in a cut-out in the centre of the top, as shown with the fan uppermost. Then bend a 'funnel' from stiff paper to fit closely around the fan without touching it. Batteries for the motor should be slung inside the body, using rubber bands to hold them in place. Use two pen cells to give three volts when connected in series, and place one each side of the centre so that the model is balanced. Use a small paper clip to connect the battery leads to the motor terminals. Removing one clip will then act as an 'off' switch.

Models like this are very easy to make, and if they are light enough will hover quite successfully. Two vents cut in one end will also provide thrust to propel the model over a smooth, flat surface.

Try other designs of hovercraft, different shapes and sizes. Pick out the lightest electric motor you can find for the power unit. Experiment with different sizes of fans, different numbers of blades, different angles for the blades.

PART SIX

Motorised plastic kits

Most of the larger scale plastic model aircraft are big enough for a small electric motor to fit inside the fuselage shells to drive the propeller. There is nothing tricky about fitting such a motor, which is done before the fuselage shells are cemented together.

PROJECT

Fitting a motor

Find a position where the motor will fit with its shaft lined up with the propeller. Secure the motor in place with wedges cut from balsa, or use modelling clay. If the motor spindle is long enough, the propeller from the kit can be mounted on it. If not, connect propeller spindle and the motor shaft with a length of plastic tube (*fig. 17*).

The next figure (*18*) shows how to motorise and wire up a display model. Thin insulated wires connected to the motor are taken down the sides of the stand to a battery box, made from balsa sheet. The plastic base of the stand forms the top of the box. The switch for turning the motor on or off can be mounted on the stand, or the side of the battery box.

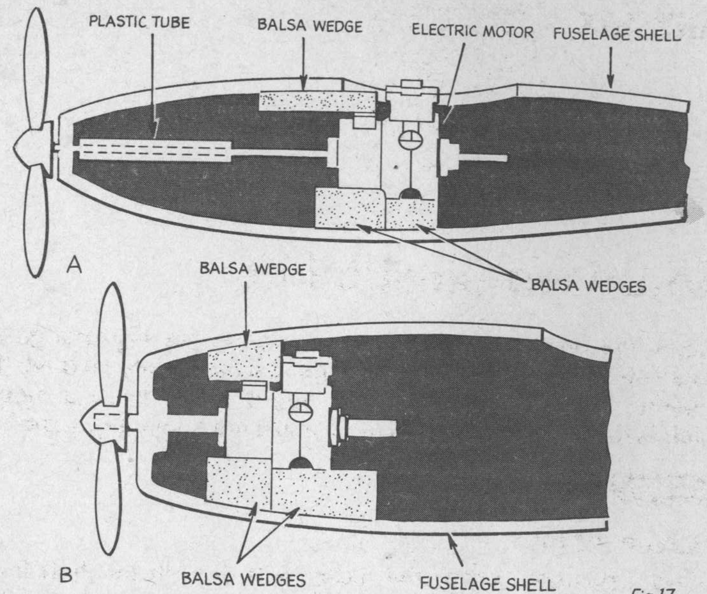


Fig 17

Multi-engine scale models can be motorised in the same way, if the engine nacelles are large enough to take a small electric motor.

In some cases it may be necessary to trim away some plastic for the motor to fit properly and allow the fuselage or nacelle shells to join neatly.

Check with your model shop:

1 What is the smallest electric motor they can supply. You do not want an expensive miniature motor, but a cheap one which only costs a few shillings.

2 Find out what plastic kit models this will fit for 'motorising'.

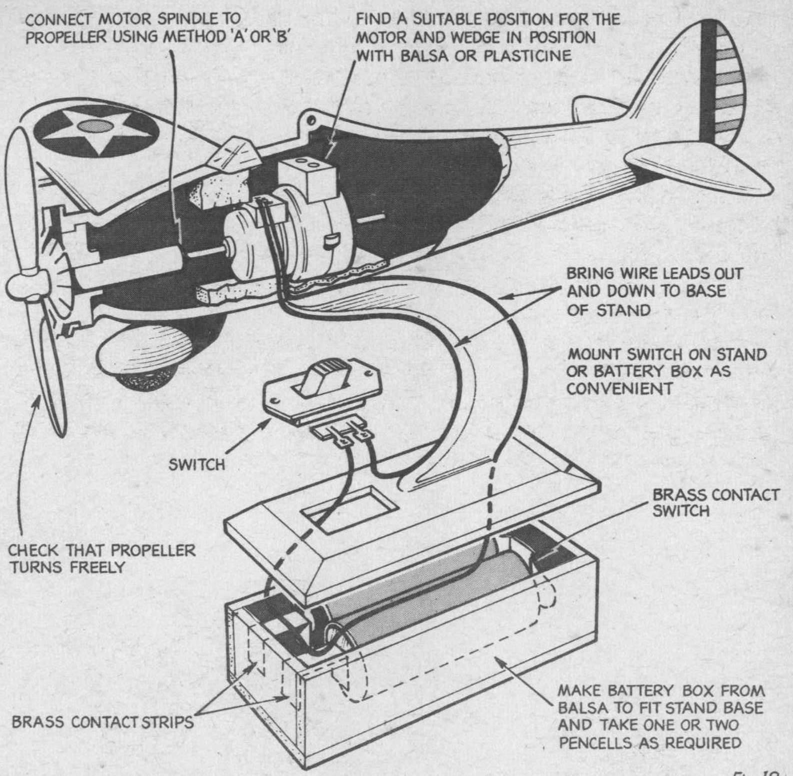

CONNECT MOTOR SPINDLE TO PROPELLER USING METHOD 'A' OR 'B'
FIND A SUITABLE POSITION FOR THE MOTOR AND WEDGE IN POSITION WITH BALSA OR PLASTICINE
BRING WIRE LEADS OUT AND DOWN TO BASE OF STAND
MOUNT SWITCH ON STAND OR BATTERY BOX AS CONVENIENT
SWITCH
BRASS CONTACT SWITCH
CHECK THAT PROPELLER TURNS FREELY
MAKE BATTERY BOX FROM BALSA TO FIT STAND BASE AND TAKE ONE OR TWO PENCELLS AS REQUIRED
BRASS CONTACT STRIPS

Fig 18

PROJECTS

Motorising other plastic models

The simplest method of motorising a plastic model car is by a rubber band and pulley drive (*fig. 19*). The motor can be mounted upright, or laid on its side. You may have to cut away some of the underbody of the car to fit the pulley.

If the model is big enough a battery can also be fitted inside the body. If not, you will have to use thin insulated wires connected to an external battery, the model running with these leads as tethering lines.

Other vehicles such as tanks, are also easy to motorise because there is plenty of room inside them for fitting a motor and drive. A speed reducing drive is necessary with these models to get them to run at realistic speeds. Use double reductions, with pulleys or gears.

Plastic ship models can also be motorised, but do not expect them to make good floating models. In most cases the hulls are too heavy to carry the weight of a motor, propeller assembly and battery, and still float. They can still be motorised as working display models, though, mounted on a stand.

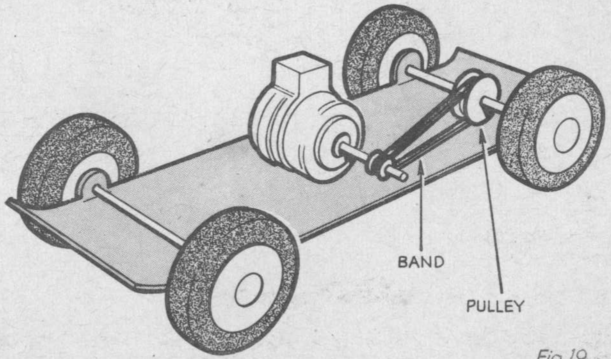


Fig 19

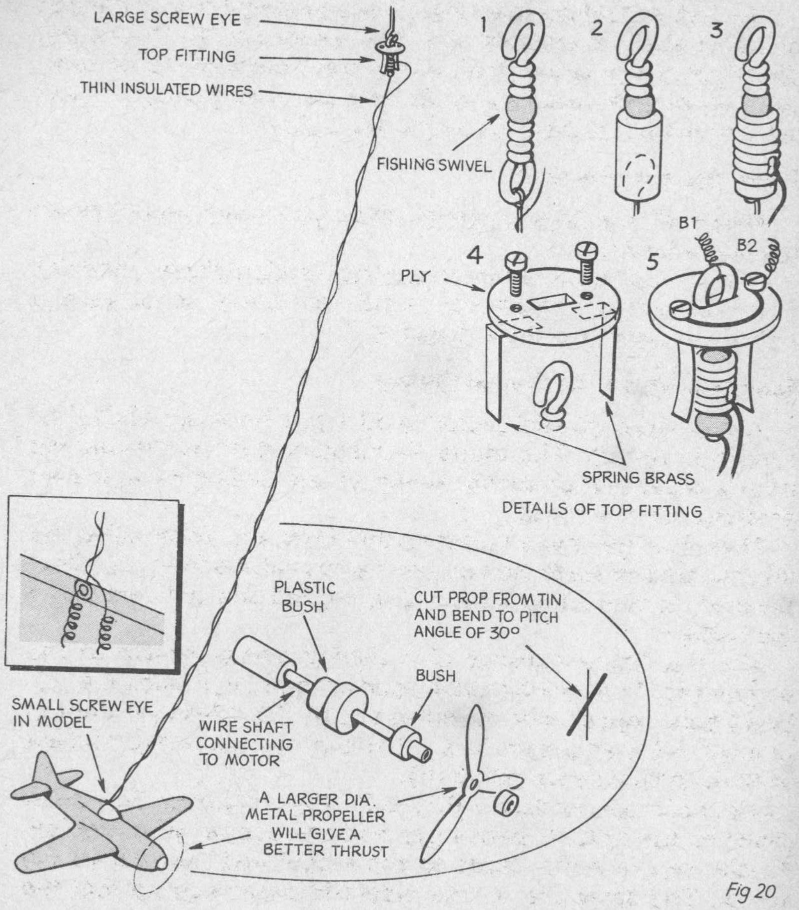


Fig 20

The hull should be fitted with a proper metal stern tube and propeller shaft of suitable size. The motor can be connected directly to the propeller shaft with a small piece of plastic tube, like the aircraft installation. Or you can use pulley or gear reduction drive, if there is room in the hull.

Find out for yourself

Which of the plastic model ships you have would make floating models?

Which could easily be motorised as working display models?

Remember that steam can scald very badly so be careful when you are doing these projects.

Motorising for tethered flying

A motorised plastic aircraft model can be made to 'fly' as shown in *fig. 20*. The model is suspended on wires running from a screweye or similar fitting in the ceiling to a smaller screweye on the model.

There is a little more to it than that however. These wires are also the battery leads, so you need a special top fitting to allow the leads to turn without becoming twisted and still connect to the battery.

The top fitting consists of a fishing swivel *shown in the diagram as* (1) over which is slipped a length of plastic tube (2). Wind bare copper wire round this tube (3). Make up the top contact (4) and assemble so that the brushes make contact with the bare wire wrapping (5).

Connect battery leads B.1, B.2. Then connect the motor leads to the bottom swivel eye and the copper wire binding. Finally secure motor leads to the model and connect to the motor. The screweye on the model is positioned so that the model balances in a realistic flight attitude.

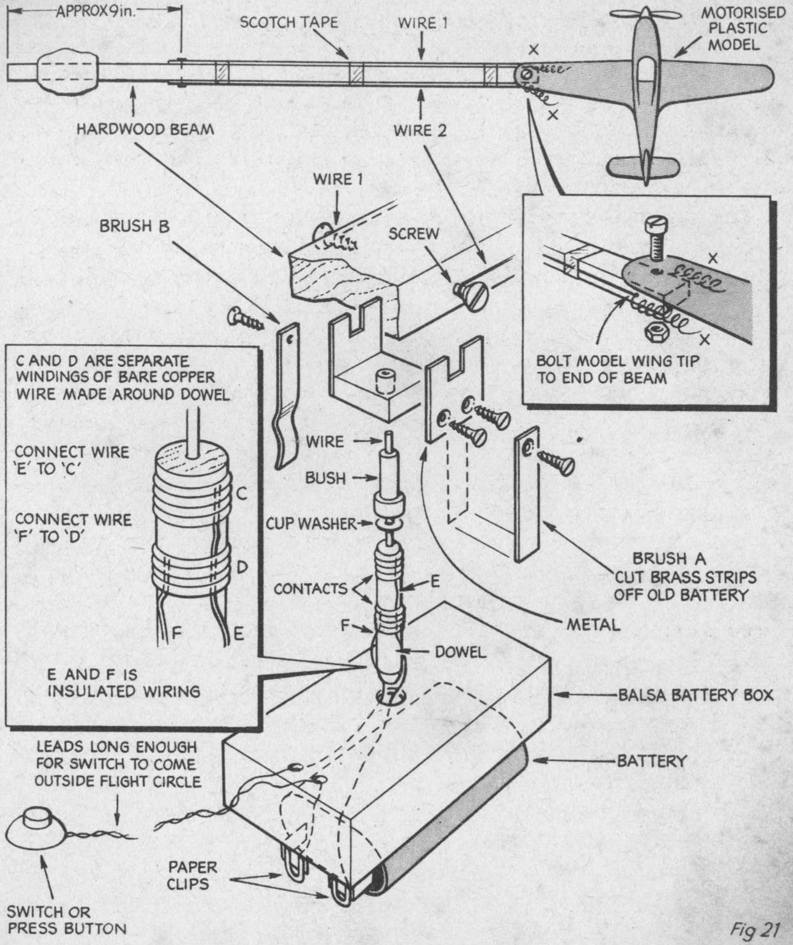


Fig 21

Motorising for round-the-pylon flying

This is a little more elaborate arrangement, but is well worthwhile as it turns a plastic kit model into a true 'working' model which can take off, fly round in circles, land again, and so on. The model is attached to a beam which rotates about a centre pylon point. (*Fig. 21*) shows how this is done.

The beam is a piece of hardwood strip, which can be anything up to 36 in. long. The wing tip of the model is bolted to one end of the beam. Small brass screws are fitted to each side of the beam about 9 in. from the other end. Wires from the motor in the model are connected to each screw, bound to the beam with cellulose tape.

Study the pylon and pivot details shown in the diagram. The pivot fitting carries the beam (pivoting on the two screws) and also brushes which run on copper wire windings C and D on the base dowel. Thus the model can move round in a circle, and up and down (with the beam 'rocking' in the centre fitting), with connection between the battery and motor all the time.

When the model is mounted, add a balance weight to the other end of the beam until the model almost lifts from the table. Switching the motor on will now make the model move forwards and lift slightly, to continue flying round in a circle. By 'blipping' the switch on and off the model can be made to taxi, or cruise, or come in for a gentle landing.

PART SEVEN

Simple steam power

You can make a simple steam engine from nothing more than a length of copper tube and it will develop enough power to drive a small model boat along quite well.

PROJECT

Copper tube engine

Such an engine fitted into a boat hull is shown in *fig. 22*. It consists of a complete one-and-a-half turn coil of copper tube, with the two ends taken back and through the stern of the boat below water level. The coil is heated by a small methylated spirit lamp or a piece of cotton wool soaked in meths and laid in a metal tray, when the boat is afloat.

After a time the boat will start to move forwards as spurts of hot water are pushed out from the ends of the tubes. This should continue as long as there is flame to heat the coil. Sometimes it works very well—sometimes not at all! You cannot be sure until you have tried it!

For bending the coil you must use soft copper tube, about $\frac{3}{16}$ in. diameter. Get a length about 3 in. longer than the length of the hull. Plug one end of the copper tube with a piece of wood carved to the shape of a cork and fill the tube with fine sand. Plug the other end with another wood 'cork'. You can now form the coil neatly by bending the tubing around a broomstick without the tube kinking. When you have made the bend, remove the plugs and shake out all the sand.

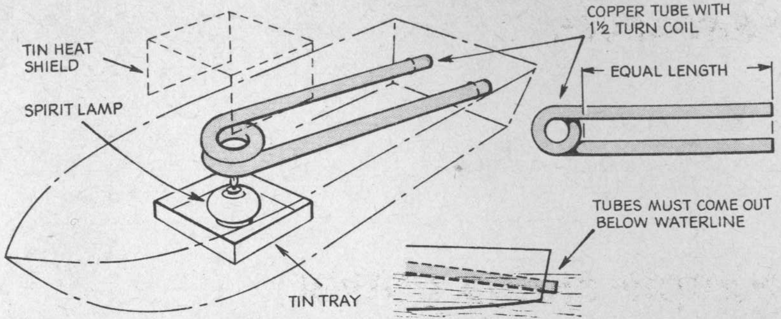

TIN HEAT SHIELD
SPIRIT LAMP
COPPER TUBE WITH 1½ TURN COIL
EQUAL LENGTH
TUBES MUST COME OUT BELOW WATERLINE
TIN TRAY

Fig 22

Secure the tube through holes drilled in the back of the hull. If the tubes are a tight fit in the holes, this will be sufficient to hold it in place. Bend upwards, as necessary, so that you can get a spirit lamp or a cotton wool 'heater' under the coil. Finally carefully cut a shield from an old tin, bend to shape to fit over the lamp and coil, and secure to the bottom of the hull.

Now try it out and see if it works.

PROJECT

Making a steam turbine

How to make a simple steam turbine is shown in *fig. 23*. The boiler is a small, and not too deep, tin can with a screw top. Support this on a simple stand. The boiler can just rest on the stand, it does not have to be fastened to it.

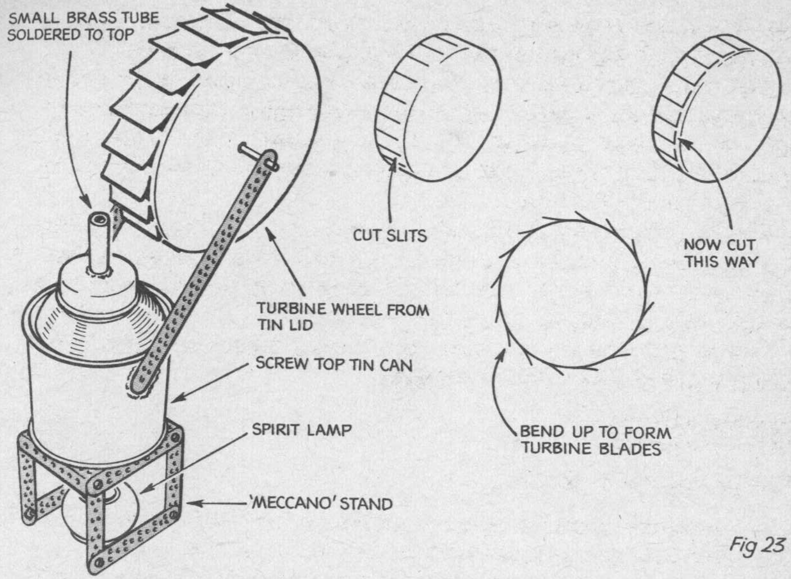

SMALL BRASS TUBE SOLDERED TO TOP
CUT SLITS
NOW CUT THIS WAY
TURBINE WHEEL FROM TIN LID
SCREW TOP TIN CAN
SPIRIT LAMP
BEND UP TO FORM TURBINE BLADES
'MECCANO' STAND

Fig 23

Drill a hole in the centre of the screw top of the can and solder a short length of $\frac{1}{16}$ in. or $\frac{3}{32}$ in. brass tube in place, as shown.

The turbine wheel is made from the lid of a larger tin can. Cut slits around the edge of this lid with tinsnips, dividing the edge up into a number of equal parts between $\frac{1}{4}$ in. and $\frac{1}{2}$ in. wide. Now cut further slits along the inner edge of each part, so that you can bend each one up to make a turbine blade.

The turbine wheel can be mounted on a 'Meccano' axle with a collar each side to hold it in place. Meccano strip should be *soldered* to the sides of the boiler to carry the turbine wheel so that it comes in the position shown. You will have to use more collars to hold the turbine wheel exactly above the pipe.

To fill the boiler, remove the turbine wheel so that you can unscrew the cap. Half fill the boiler with water, replace the cap, screwing it down tight, and the turbine wheel. Put a small spirit lamp under the boiler, light it and wait for steam to emerge from the small pipe at the top.

The steam should soon build up into a high pressure jet. This jet, striking the turbine blades, will drive the turbine wheel round at a high speed. This will continue as long as there is water in the boiler, being turned into steam.

Remember that steam can scold very badly so be careful when you are doing these projects.

PROJECT

Further experiments:

Try other sizes and shapes of turbine wheel—different number of blades, different shape for the blades, and so on.

See if you can make a turbine wheel which develops enough power to drive a light model through a pulley and belt drive.

If you already have a model steam engine, disconnect the piston and flywheel assembly from the steam pipe from the boiler and replace with a home-made turbine wheel. Position the boiler steam pipe so that the steam strikes the turbine wheel properly. Does this run better than your tin-can boiler model?

To make a proper steam engine satisfactorily you really need a lathe, and you must also be able to silver solder. Ordinary soldered joints are no good for a proper boiler. Unless you are an experienced model engineer, therefore, the best way to make a more powerful steam engine is to buy a kit of parts and a ready-made boiler.

PART EIGHT

Diesels and glow motors

Diesels and glow motors are internal combustion engines which run on fuel. They have been specially developed as power units for models. The Diesel is a very much simpler version of the full size Diesel engine. The glow motor is really the model version of a petrol engine, and again very much simpler. It does not need a spark plug and electrics to go with it. Instead it uses a glow plug which fires the fuel automatically only this time it has to be an alcohol fuel, not petrol.

Both types of engines are used mainly for powering model aircraft. They can also be used for powering model boats, but this introduces two problems.

First, cooling. All internal combustion engines have to be cooled when they are running. A car engine has a radiator and a fan to provide its cooling. Used on a model aeroplane, a Diesel or glow motor receives all the cooling it needs from the draught caused by the propeller. Put the same engine into a boat and there is no propeller to provide cooling. The aero engine, therefore, has to be converted for boat use by fitting it with a water cooled head (*fig. 24*).

This is really a hollow jacket surrounding the cylinder. It is fed with water from a scoop positioned behind the boat propeller, connected to the head by a length of plastic pipe. Water then escapes from the jacket through another pipe, led overboard.

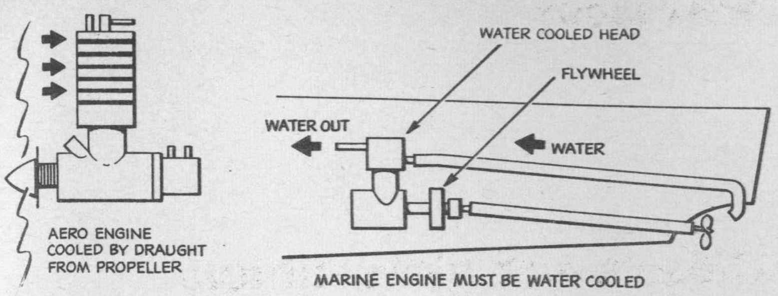


Fig 24

Second, the drive. To make the engine run smoothly when driving a very small propeller like a boat propeller it also needs a flywheel. This replaces the airscrew which also acts as the flywheel in the case of an aero engine. It is then necessary to add a flexible coupling to connect the flywheel drive to the propeller shaft (*fig. 25*). The propeller shaft cannot be connected rigidly to the flywheel as this would cause too much vibration if it was even the slightest bit out of line.

Using a Diesel or glow motor in a model boat, therefore, requires the following:

1 Using a 'marine' version of the engine with a water cooled head. Most popular makes of Diesels are also produced in 'marine' versions although very few glow motors are produced in 'marine' version.

2 A matching size of flywheel. A 'marine' version of an engine is usually supplied complete with flywheel.

3 A suitable type of flexible coupling to connect the flywheel to the propeller shaft in a boat installation. This depends on the

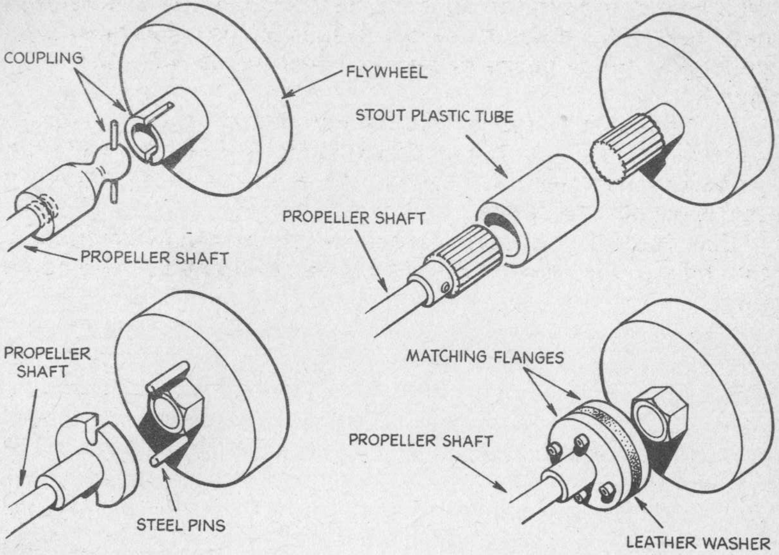


Fig 25

size of the engine and the power it develops. You can buy a matching size of coupling from any model shop.

Stationary models

If you want to use a diesel or a glow motor to drive a stationary model, then you have the same sort of cooling problem. You really need a 'marine' version, where you can arrange a supply of cooling water from a tank mounted above the engine. (*See fig. 26.*)

There is another problem, too. Driving a flywheel with no other load, the diesel may run at a speed of 10,000 rpm or more, which is far too high to drive any stationary model. You would need to cut this down by several stages of reduction gearing—preferably pulley drives rather than gear drives. (*See also Part Five.*)

All told, in fact, model internal combustion engines are not really suitable for driving stationary models. They are really too powerful, and they run too fast. An electric motor of suitable size is usually far better.

Can you think of stationary units which would be suitable for driving by a small diesel? (A dynamo or generator would be one).

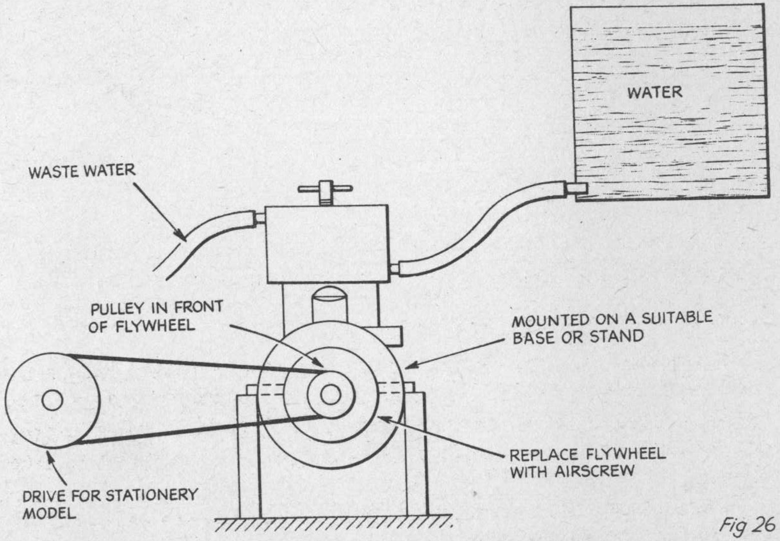

WATER
WASTE WATER
PULLEY IN FRONT OF FLYWHEEL
MOUNTED ON A SUITABLE BASE OR STAND
REPLACE FLYWHEEL WITH AIRSCREW
DRIVE FOR STATIONERY MODEL

Fig 26

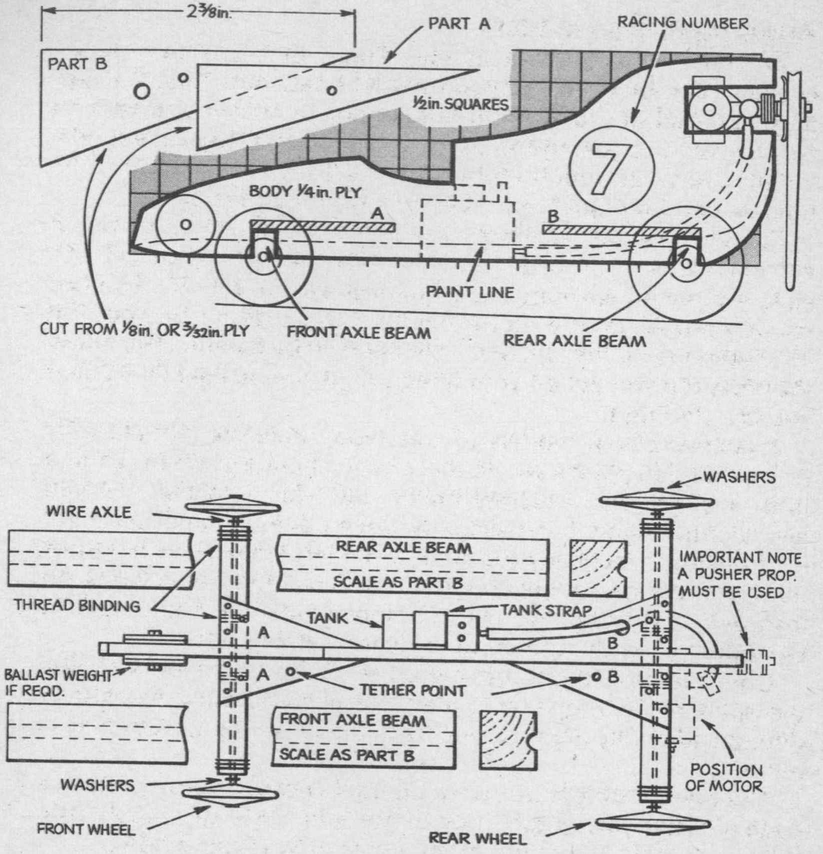


Fig 27

Airscrew-driven models

We have already seen in Part Three that a rubber-driven airscrew can be used to power model boats and cars. An aero engine diesel or glow motor is a complete airscrew drive, and can be fitted to just the same types of models. Because model engines have so much more power than a rubber motor, the models can be bigger, and they will go much faster.

For example, *fig. 27* shows a suitable design, and size, for an airscrew-driven car with an 049 glow motor or Diesel. An airscrew-driven speedboat design is shown in *fig. 28*. The fast revving propeller on a model engine can cause a nasty cut if it hits someone on the leg, or on the hand so be careful. You know the nasty rap you get on your fingers if an engine backfires when you are starting it.

Airscrew-driven models of this type, therefore, should only be operated in places where there is no chance of them running into anyone. An airscrew-driven car, for instance, should always run tethered. An airscrew-driven boat is much safer, for it is unlikely to meet anyone in the pond! But make sure it is not a nuisance to other model boat owners. Airscrew-driven boats are *fast*, and if they collide with another boat they could sink it. Operate only when the pond is clear of other craft.

One final tip. Round off the edge of the propeller with fine glasspaper. The propeller is then less likely to cut if somebody does accidentally get their fingers in the way when the engine is running.

The main problem in using a model Diesel or glow motor is usually what size engine goes with what size of model? The following table is a guide for all types of working models.

Add to the table overleaf, listing available engines under the different engine sizes shown.

Also add a list of suitable kit models which fit in the various

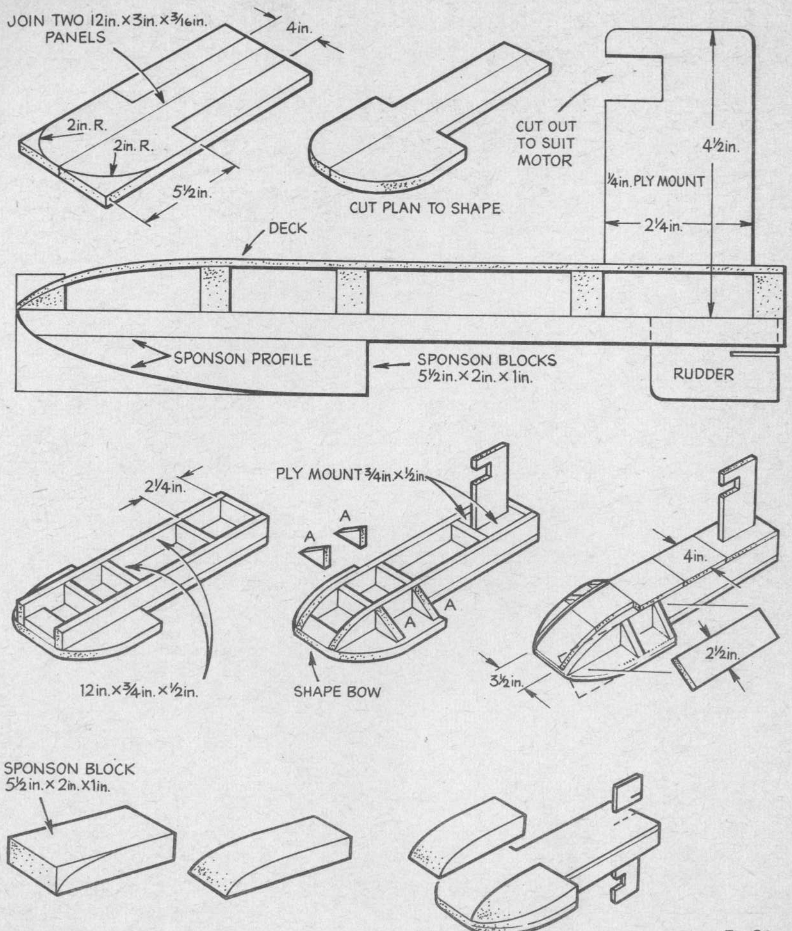


Fig 28

sizes. Keep the list up to date as new kits and new engines appear.

MODEL ENGINE SELECTION TABLE

	Size Cu. in.	C.C.	Free Flight Aircraft *span*	Control Line Aircraft *span*	Airscrew Driven Boats *length*	Airscrew Driven Cars *length*	Prop. Driven Boats *length*
			All measurements in inches				
Glow Motors	.02	—	12–18	8–10	6	5	—
	.049	—	24–32	10–15	8–10	6–8	—
	.09	—	34–40	18–24	10–12	8–10	—
	.15	—	40–50	24–36	12–14	8–12	—
	.19	—	48–60	32–44	16–20	8–12	—
Diesels	—	.5	24–30	12–18	8–10	6–8	15–18
	—	.8	30–36	15–20	10–12	6–8	18–22
	—	1	34–40	20–30	12–14	8–10	20–25
	—	1.5	36–45	24–32	14–16	8–10	24–28
	—	2.5	45–55	30–44	16–18	8–12	28–32
	—	3.5	55–70	36–54	16–24	8–12	32–36

Note: Glow motor sizes are always given in *cubic inch* capacity.

Diesel engine sizes are always given in cubic centimetre (c.c.) capacity.

To convert from one 'size' to the other, remember 1 c.c. = .061 cu. in. and 0.1 cu. in. = 1.64 c.c.

PART NINE

Jets and rocket propulsion

Unfortunately a scale model jet engine just does not work. The only type of full size jet engine that can be made to work in miniature size is the pulse jet—the type of engine used by the German VI Flying Bomb of the Second World War. But these miniature engines are expensive to buy, noisy and dangerous.

The nearest we can get to a model jet turbine engine is a ducted fan. This is an ordinary aero engine driving a multi-blade propeller or fan of fairly small diameter, the whole being enclosed in a circular tube (*fig. 29*). By careful shaping of the tube or duct, the thrust that can be obtained from such a set-up is nearly as much as could be obtained from the same engine driving an ordinary propeller. If the duct shape is wrong, then the thrust is very much less.

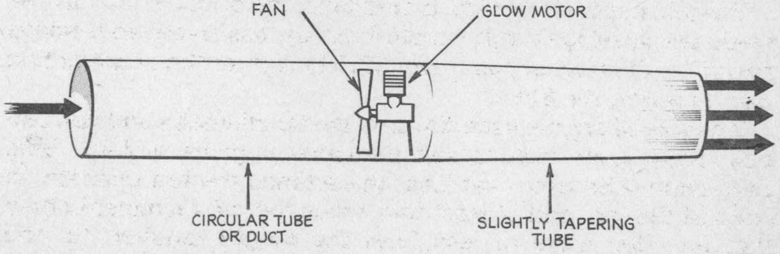


Fig 29

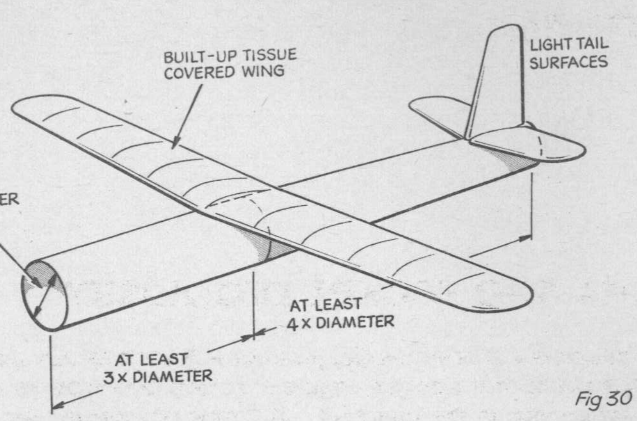


Fig 30

PROJECTS

A ducted fan model

Producing a successful ducted fan model is very much a matter of 'cut-and-try'. It is useful only for aircraft propulsion, the ducting being enclosed within the fuselage.

To gain experience with ducted fans, the duct can, in fact, be made the fuselage, with simple built-up tissue-covered wings and tail unit attached, as in *fig. 30*. The lighter the construction can be made, the better.

The size of engine used governs the fan diameter and you can buy ready-made fans to suit particular engines. A fairly long duct should be used—at least three times the fan diameter in front of the fan, and at least four times the fan diameter behind the fan. This more or less fixes the length required for the fuselage. The rear duct should taper slightly, but its end area should not be less than three-quarters of the area of the centre ducting.

Small glow motors are normally used with ducted fans, since they are lighter than Diesels and easier to start.

If you fancy yourself as a model aircraft designer—here is your chance. Have a go at a simple ducted fan model.

Rocket engines

For small models, the only practical form of jet propulsion is the rocket engine, which burns a solid fuel. This is really like a firework rocket, except that it has a metal case with a specially shaped 'jet' end, and takes replaceable pellet charges. The charge is fired by igniting a special fuse, fitted when the pellet is placed in the rocket body.

The unit of this type which you can buy in this country is the 'Jetex'. This is available in three different sizes, the sizes of models which match these units being shown in the following table:

TABLE—JETEX MOTORS

	AIRCRAFT size		*SPEEDBOAT*	*CAR*
Jetex	*span*	*weight*	*length*	*length*
Atom (35)	10–12 in.	½–¾ oz.	6 in.	5 in.
50	18–20 in.	¾–1 oz.	7–8 in.	5 in.
150	24–36 in.	1–1½ oz.	9 in.	7–8 in.

Note that a Jetex unit can be used to power model cars or speedboats, as well as model aircraft. (*See fig. 31.*) All these models must be lightly built so that they will pick up speed quickly as the Jetex charge starts burning and developing thrust. A charge will only burn for about five seconds, so the duration of thrust is quite short.

This is still sufficient to carry a light model aeroplane to a good height, or carry a model speedboat at high speed right

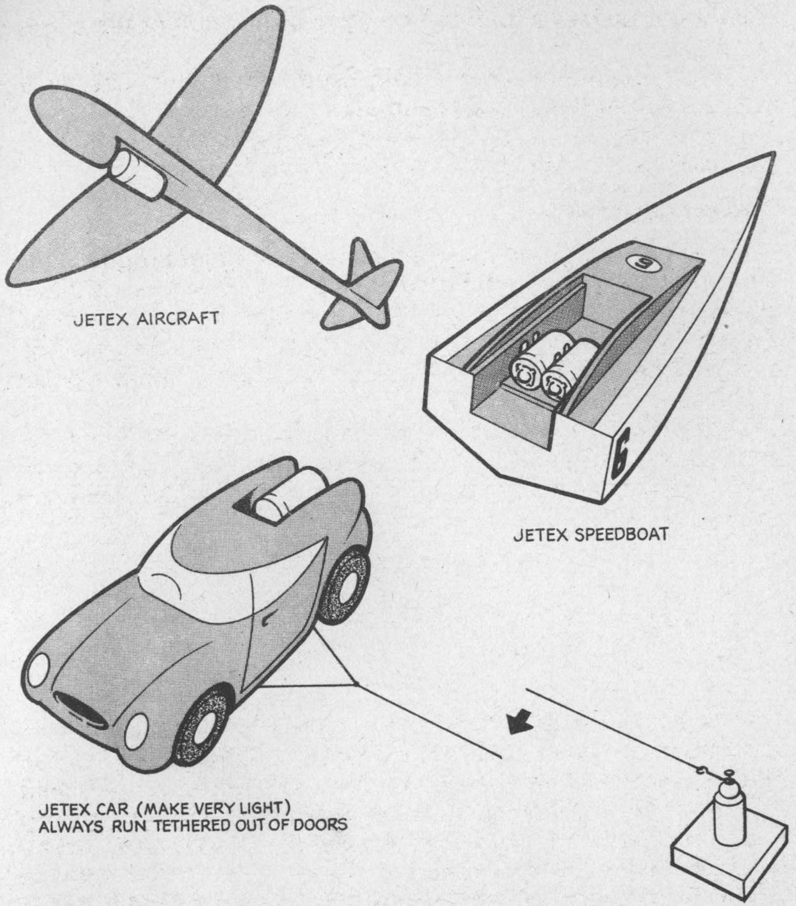
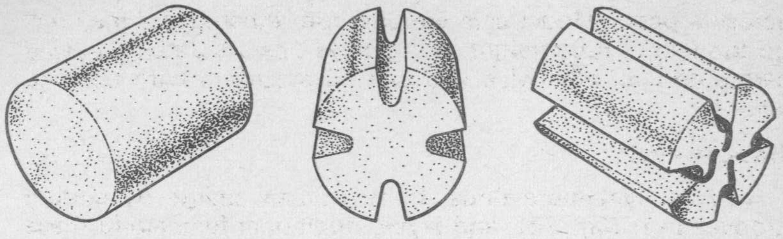

JETEX AIRCRAFT
JETEX SPEEDBOAT
6
JETEX CAR (MAKE VERY LIGHT)
ALWAYS RUN TETHERED OUT OF DOORS

Fig 31



NORMAL CHARGE SHAPED CHARGE WITH ADDED FUSE

Fig 32

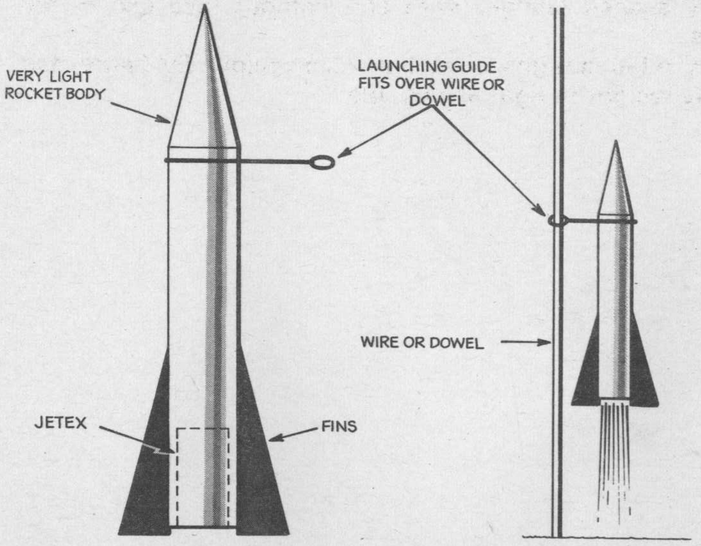


Fig 33

across a pond. Model cars are best run tethered, for they will go too fast to run straight. But always operate Jetex powered cars outdoors, otherwise you will fill the room with choking smoke.

Rocket craft

You can get more thrust from a Jetex charge by cutting grooves in it (*fig. 32*), and laying additional fuse along these grooves. It could, for example, lift a very light rocket body up vertically, like a real rocket launch (*fig. 33*).

1 Try cutting the charge to other shapes to see if you can get more thrust and more height from your rocket.

2 Try shaped charges with and without fuse laid in the grooves.

3 Try other designs of rocket which might fly better, but keep the weight as light as possible.

PART TEN

Radio control

Radio control is the ultimate, as far as working models are concerned.

With radio control you can pilot a model aeroplane in flight (powered models or gliders); operate a model boat under complete control (steering, engine ahead-stop-astern, and other services); or steer and control the speed of a free-running model car.

There are three main types of radio control:

1 Single-channel systems which operate by switching a single signal on and off. This can be used to operate a single control movement in sequence. For example, the sequence could be

First signal—Left rudder—return to neutral with signal off.
Second signal—Right rudder—return to neutral with signal off.
Third signal—Left rudder—and so on.

It is also possible to operate further controls by introducing them into the sequence.

2 Multi-channel systems which can send several different signals. Each signal can then operate a separate control on an on-off basis similar to the above.

3 Proportional systems which can send several different signals each of which can be varied. Each signal can then operate a control over a whole range of movement. Movement of a rudder on a model, for example, would follow exactly the amount of movement given on the control click of the transmitter.

Obviously a proportional system is best, because it gives complete control. It is also the most expensive. A complete proportional control outfit can cost anything from about £125 to over £300. A multi-channel system is a bit cheaper, but not all that much if you want a large number of channels. Single-channel systems are very much cheaper, but still cost about £15 as a minimum. There is no escaping from the fact that radio control **is** expensive.

How radio control works

The essential components in any radio control system are a transmitter and receiver, and an actuator. In a single-channel system the receiver really acts like an on-off switch, following exactly the on-off signal given by keying the transmitter. The receiver 'switching' action causes the actuator to move to a control position when signalled 'on'. When signal 'off' is received, the receiver switches off the actuator circuit, and the actuator returns to its neutral position. On the next signal 'on', the actuator moves to the opposite control position—and back to neutral again when switched off by the receiver.

How this can be used to operate a rudder on a model aeroplane or boat is shown in *fig. 34*.

To repeat the same control movement, it is necessary to signal through the other rudder position first. For example, suppose left rudder was wanted, and after this signal had been released, left rudder was wanted again. The signals required on the transmitter key would be . . . press and hold to give left

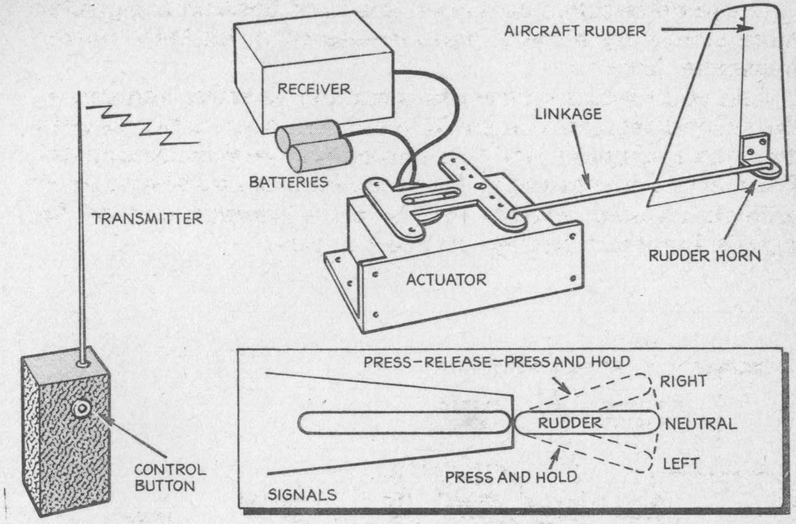


Fig 34

rudder . . . release to allow rudder to return to neutral. Press-release-press and hold . . . to give left rudder again.

Most actuators are designed to sort out sequence signals for themselves. They are then known as selective actuators. With a selective actuator 'press and hold' would always give left rudder (or right rudder, depending on the way it is connected up), while 'press-release-press' and hold would always give right rudder (or left rudder).

It is also possible to provide a third position on a selective actuator, which would be signalled by . . . press-release-press-release-press and hold. This third position can be used to select and operate another actuator to operate another control such as the engine throttle. (*See fig. 35*.)

On some selective actuators, this third position is signalled more simply by a quick press-release or quick 'blip' on the transmitter key.

Can you work out how using another selective actuator as the second actuator you could use this to operate two or even three more actuators, and thus two or three additional controls? This can be done, as a way of getting a lot of controls working off a single-channel system. This is not a practical method for aircraft, but it can be used on boats or cars.

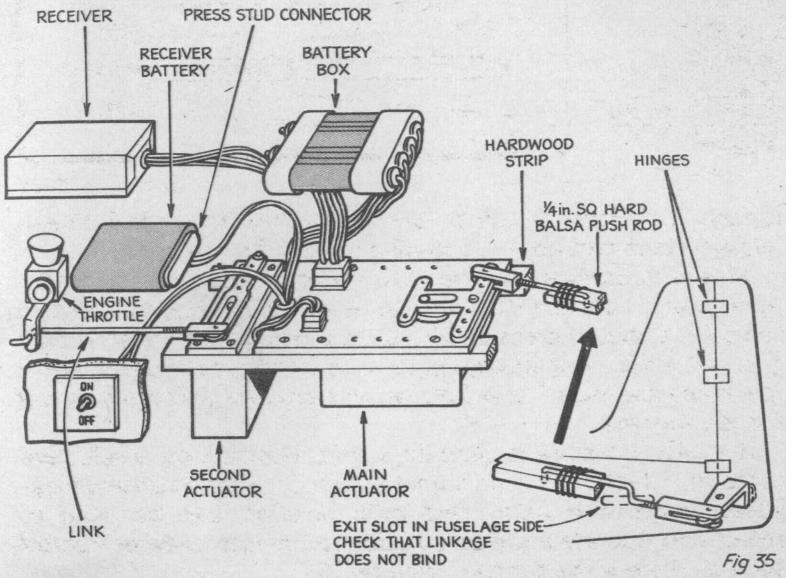


Fig 35

PROJECTS

Here are some more advanced ways you can experiment with model radio controls.

1 Switching a radio set on and off from a distance (use the actuator movement to operate the radio on-off switch).

2 Tune a radio set in to different stations from a distance. (Use the actuator movement to drive the tuning knob through suitable gearing.)

3 Switch channels, or operate the volume control, on a television set from a distance (from your armchair, to save you having to get up!).

4 Open and close garage doors from a transmitter in the car. (The actuator switches a relay capable of carrying sufficient current to switch a powerful electric motor on and off. The motor opens and closes the door through suitable linkage or gearing.)

Work out other things you can do with radio controls.

●Note: to operate radio controls you must have a licence. This can be obtained by writing to:

The Post Office Radio and Broadcasting Department,
Waterloo Bridge House, Waterloo Road, London SE1.

A licence costs 30s. and is valid for five years.

FOR FURTHER READING

Beginner's Guide to Radio Control, by R. H. Warring. *Lutterworth Press*

Boys' Own Book of Power-Driven Models, vy R. H. Warring. *Lutterworth Press*

Electric Model Car Racing, by D. J. L. Dickson. *Museum Press*

Model Boilers and Boiler Making, by K. N. Harris. *Model and Allied Publications*

Model Cars Encyclopaedia, by D. J. L. Dickson. *Model and Allied Publications*

Model Electric Railway Construction. *Cassell,* (**New Model Makers** series).

Model Engines, by R. H. Warring. *Arco*

Model Mechanical Engineering, by E. A. Steel. *Cassell*

Model Petrol Engines, by E. T. Westbury. *Model and Allied Publications*

Model Power Boats, by R. H. Warring. *Arco*

Model Stationary and Marine Engines, by K. N. Harris. *Percival Marshall*

Model Steam Locomotive Construction, by M. Evans. *Model and Allied Publications,*

Model Steam Locomotive Designs and Specifications. *Cassell,* (**New Model Makers** series).

Model Steam Locomotives, by H. L. Greenly. Revised by E. A. Steel. *Cassell*

Multi-Channel Radio Control, by R. H. Warring. *Model and Allied Publications*

Power-Driven Ship Models, by A. D. Trollope. *Model and Allied Publications*

Radio Controlled Models, by R. H. Warring. *Museum Press*

Radio Controlled Transistor Circuits for Models, by H. Boys. *Bernards*

Simple Electric Car Racing, by V. E. Smeed. *Model and Allied Publications*

Single Channel Radio Control, by R. H. Warring. *Model and Allied Publications*

Sub-Miniature Electric Motors, by R. H. Warring. *Arco*

Working Models, by V. E. Smeed. *Arco*

To buy any of the above books, first try your local bookseller. If he does not have it in stock, he will be pleased to order it for you. In case of difficulty, write to the publisher of the book in question.

POSSIBLE CAREERS

ENGINEERING DRAUGHTSMANSHIP. This means making the drawings of all the parts of a machine to be manufactured. Age of entry is usually 15 to 18 years, with 'O' levels in mathematics and science, or first-year Ordinary National Certificate in Engineering. Training is by a five-year apprenticeship.

Read: Engineering Draughtsman, Choice of Careers Booklet No. 60 (from booksellers or Her Majesty's Stationery Office).

Write to: The Institution of Engineering Designers, 38 Portland Place, London W.1; The Draughtsman's and Allied Technicians' Association, Onslow Hall, Little Green, Richmond, Surrey.

MECHANICAL ENGINEERING—designing, making, installing, operating and maintaining machines of all kinds. You can take up this career at various levels, from leaving school at 15½ up to taking a university degree in mechanical engineering. For a five-year apprenticeship you need a sound general education, especially in mathematics and science. For a four- or five-year student apprenticeship, starting at 16–19, you need four or five 'O' levels in English, mathematics and a science subject.

Read: Engineering Work for Boys, Choice of Careers Booklet No. 78; **Professional Engineers,** Choice of Careers Booklet No. 92 (from booksellers or Her Majesty's Stationery Office).

Write to: Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1.

MODEL MAKING. The production of small-scale models in many kinds of materials, for architects, town planners, film sets, museums and exhibitions. Entry to the career is usually from 16 upwards, after a technical college or art school course.

Read: Model Making as a Career, by T. W. Hendrick (Percival Marshall); **Model Engineer,** a weekly magazine.

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